Three-Dimensional Modeling of Power Distribution Systems

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Abstract—Developing low-cost, compact, densely packed, and high-performance Monolithic Microwave Integrated Circuits (MMIC's) is a major technology thrust. Rigorous analysis tools are needed to reduce the time and cost of the hardware iterative design cycle, and to increase the probability of first pass designs and to provide reliable predictions of the performance parameters. One of the analysis tools, that is straight forward, versatile, and has acquired many new applications, is the Conformed Orthogonal Grid, Finite-Difference Time-Domain (COGFDTD) technique. Several researchers use a simpler Uniform Grid Finite Difference Time Domain (UGFDTD) technique in modeling a variety of devices, ranging from complex high-speed devices to simple microstrip discontinuities. The COGFDTD technique is superior to the UGFDTD in its ability to match all circuit's dimension, hence eliminating a major source of error.

Currently, the quasi-static analysis which is based on empirical low-frequency formulae is used to model a variety of structures from simple discontinuity to complex three-dimensional power distribution systems. This quasi-static analysis does not accurately evaluate the characteristics of power distribution system at microwave frequencies since it does not account for radiation, coupling, fringing, and wave propagation effects. The COGFDTD is superior to the quasi-static analysis, which in such cases, provides a more rigorous (an exact, or full-wave) solutions of Maxwell's equations. Also, the COGFDTD technique provides the capability of simulating the entire circuit structure in one computation, over the entire frequency domain from dc to the desired cutoff frequency. The generalized COGFDTD technique, presented in this paper, matches all orthogonal circuit dimensions using the staircase-type approximation and proves to be flexible in handling a variety of complex circuit configurations.

Three sample structures are selected from a variety of test cases to demonstrate the versatility of the COGFDTD technique and for the verification of the model. The three structures are 3-dB power dividers, namely a modified wilkinson, a Rat-race, and a

Gysel. All the circuits represent resonant microstrip structures fabricated on an open substrate at the Ka-band range; hence, radiation and coupling effects dominate the performance significantly. The results of using the conformed orthogonal grid technique to the prediction of frequency-dependent scattering parameters for complex geometry power distribution systems are presented. The COGFDTD results are further compared with experimental measurements of scattering parameters for the fabricated circuits, and other commercial software tools for the same circuits.

The results will be presented in the form of a video tape visualizing the electric and magnetic fields and the frequency dependent parameters.